AMERICAN SOCIETY OF CIVIL ENGINEERS.
INSTITUTED 1852.

TRANSACTIONS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

CCXXXV.
(Vol. XI.—April, 1882.)

ON THE REMOVAL OF INCRUSTATION IN WATER MAINS.

A DESCRIPTION OF THE OPERATIONS PERFORMED IN HALIFAX, N. S., CANADA.

By E. H. KEATING, M. INST. C. E., CITY ENGINEER AND ENGINEER OF THE WATER WORKS.

READ MARCH 15TH, 1882.

The City of Halifax is supplied with water from two distinct sources.

The high service supply is drawn from the Spruce Hill Lakes, elevated 360 feet above city datum or mean low-tide, and about 8 miles from the heart of the city. The main consists of 6 500 lineal feet of 20 inch, and 29 500 feet of 15 inch pipe, and furnishes water to all localities, exceeding about 125 feet above tide level.

The low service supply which delivers water to nearly all the remaining portion of the city is drawn from Lower Chain Lake at an elevation

of 199.40 feet above the same datum, and about 4 miles from the heart of the City.

The main is a continuous one of 24 inches in diameter, and about 13 500 feet in length. It was laid in 1862, was cast in Glasgow, and was well coated with a preparation of coal tar pitch apparently the same as that known as the patent of Dr. Angus Smith.

All the pipes of the high service main were also made in Glasgow. The 20-inch and the first 16 100 feet of the 15-inch pipes were laid in 1868, and were similarly coated to those above described. The remaining 13 400 feet of 15-inch pipes were laid in 1856, and do not now appear to have been originally coated with any preservative preparation.

The Engineers who advised the construction of the works, estimated the capacity of the high service main at 2,000,000 gallons and the low service main at 5,000,000 gallons daily.

There was not and is not yet any ready method by which the actual quantity of water delivered into the city could be measured or gauged with any degree of accuracy. It became evident, however, after the lapse of years, that the works were not performing anything like their estimated duty, and that their capacity was gradually decreasing. The pressure ultimately became so poor in some localities that the water would not flow from the nozzles of the hydrants, nor even in the basements of some of the houses.

The efforts made to overcome the difficulty consisted in :

1. Energetic searches after underground leaks.

2. The partial or entire closing of many of the valves on the distribution mains throughout the city.

3. The partial diversion of the high service supply into the low service system of pipes.

4. The substitution of larger pipes in some localities.

5. A general inspection of all the internal pipes and fittings, with instructions to shut off the supply wherever excessive waste was detected.

6. The passing of an ordinance authorizing fines to be imposed for the "unnecessary waste" of water.

These provisions did not greatly lessen the evil. Complaints of "short supply" and of "no supply at all" continued to be made, and were annually on the increase. Instances are on record when some hundreds of such complaints were made in a single day. The difficulty, of course, was most generally felt during the winter season, and especially during a

sharp snap of frost, when many householders—to avoid the risk and dangers of frozen service pipes—are in the habit of allowing a copious stream to run from every faucet on their premises.

The author first became connected with the works in 1873. After carefully going into the original calculations he became satisfied that the Engineers who first reported upon the discharging powers of the mains, had not made any mistakes in that respect, *i. e.*, assuming the generally accepted rules to be correct. They had, in fact, judiciously, rather understated their capacity. A very short time, however, elapsed before the principal cause of the troubles was found to be within the pipes themselves, in the shape of a rough, hard and thick incrustation of oxide of iron. Although it had long been known that the pipes were badly corroded, the actual extent to which this corrosion existed, and its damaging effect upon the water supply, did not appear to have been suspected.

In some of the oldest pipes the concretion was found to be over 1¼-inch in thickness. Many miles of pipes of 3 inches in diameter had originally been laid within the city; these were in some places almost closed against the passage of water, and the old 6-inch pipes were reduced in internal diameter to from 3¼ to 3½ inches. The mains leading to the city were, on examination, found similarly incrusted, though to a smaller extent, as they had not been as long laid as the pipes above described.

The first attempts to remove the incrustation by mechanical means were made in 1875, when over 5 miles of the old 3 inch distribution pipes were cleaned by a scraper attached to iron rods and propelled by hand. The machine consisted of four arms or knives attached to a centre and sprung outwards against the inner surface of the pipe by a thick rubber disk. The usual process was, after cutting out a length of pipe, to insert the scraper, turn on a good run of water against it, and gradually work it ahead for 150 or 200 feet. A small steam pump was used to keep the trench clear of water. The pipes cleaned in this manner had been laid for about 28 years. The following quotations on this subject are from the civic report of 1875. "It has been customary during the last six or seven years, as these pipes were found gradually to fill up by oxidation and concretions, and became insufficient for the supply, to lift them and put down pipes either of the same or larger diameter. On examination during the past summer, it was ascertained that those still remaining—of which there are about seven miles—had contracted to 1⅛ and 1¼ inch in size. * * *."

"The work of boring or scraping out five miles of these old pipes, and restoring them to their original internal diameter, was given to contract for $3 750, or at the rate of $750 per mile, the city supplying the necessary new pipes and sleeves to make good the connections. The contractor was held responsible for any damage that might result in the process of cleaning, and he was not allowed to have the water turned off of any street or district for more than twenty-four hours."

In the following year 6 385 lineal feet of 3-inch water-pipes were cleaned out in a similar manner by the same contractor and at the same rate as previously paid, viz.: $14\frac{2}{10}$ cents per lineal foot. There were extras on account of old leaks discovered and repaired, to the amount of $29.86, making the total cost $936.53.

The author considered the rates paid on the above contracts excessive, but his advice that the work should be done by the Water Department by days labor was overruled. The process, although effective for a time—besides being slow, laborious and expensive—was practically inapplicable to pipes of large diameter, and it was the incrustation in the large pipes which was so seriously affecting the water supply to the city.

The first effort to remove the incrustation from the larger pipes by mechanical scrapers was made in 1880, the following description of which is quoted from a local newspaper of the 14th October of that year:

"It may not be generally known outside of engineering circles that cast-iron water-pipes, after being in use a few years, become more or less corroded, so as to seriously affect the flow of water through them and diminish the water pressure which, when new, they are capable of affording.

"This matter has for some time been under consideration by our Board of Works, who latterly, on the advice of the City Engineer, decided to try the experiment of scraping out some of the large pipes by means of a novel little machine known as a mechanical pipe scraper, * * * * * * * * and yesterday, at three o'clock, was fixed upon as the time for the trial. The pipe selected for the experiment was one of twelve inches in internal diameter, leading from St. Andrews Cross over the North Common and down Cogswell street as far as Brunswick street, a length of 3 200 feet." (Plate III.) "This pipe was selected by the Engineer on account of its being the oldest in the city, having been laid by the late Halifax Water Company in 1848. The thickness of incrustation on the inside of the pipe had been observed to be a little

more than one inch, so that the inside diameter was actually reduced to less than 10 inches, besides being very hard and rough. The North Common being at a high level, with inclinations both down and up-hill, and the pipe being the worst one known, it was considered that, if the experiment on this length proved successful, there could be no risk in undertaking to scrape out all the pipes through the streets and the mains from the lakes. A few gentlemen, including the press reporters, who had taken an interest in what was going on, assembled at St. Andrew's Cross to see the machine put into the pipe and started on its journey. The pipe cover having been securely bolted to its place, the water was turned on at 3.30 o'clock P. M., and although the watchman in the trench, and others stationed along the line with their ears to the ground, reported that they could not detect any movement in the machine by the sounds it was expected to make while passing along, the watchman, with his ear to the pipe about a quarter of a mile off, soon came running to say that the scraper had passed his station about five minutes after the water had been turned on. A general rush was then made for the outlet at the foot of Cogswell street, where it was expected to emerge almost immediately. On arriving at that point, a large stream of black water was seen rapidly issuing from the open end of the pipe, but this soon ceased, and it was feared that the little machine had stuck fast in the pipe at some point, and was lost somewhere within the last half mile. Just as all hope for its reappearance was about to be given up and the experiment pronounced a failure, a dense mass of 'black muck' of many tons weight was suddenly seen to issue from the end of the pipe, and immediately afterwards a perfect torrent of black and muddy water. This occurred about thirty minutes after the scraper had been started, and it was then known that the machine had performed its task and must be somewhere embedded in the heap of iron rust, mud and dirt in the trench. The water having been shut off and somewhat subsided, the scraper was then fished up out of the trench, greatly to the relief of mind of all concerned. Arrangements were then made for passing it through the same length of pipe a second time, so that it would be more thoroughly cleaned; but the party assembled being perfectly satisfied with the first trial, dispersed."

The next operations of the same kind were performed on the Brunswick street 12-inch main for a length of 3 800 feet; but owing to obstructions in the pipe, the piston leathers being much worn and the steadily rising gradient which had to be overcome, the scraper was four hours in

making the first trip. It halted in its progress on several occasions, and once remained stationary for so long a time that it was feared the main would have to be cut open to get it out. The second run was made in an hour and fifteen minutes, with the piston leathers in the same worn out condition, and the next in a somewhat shorter time.

This concluded the operations for 1880. The scraper so far used being the experimental one, imported from an engineering firm in Kilmarnock, Scotland, the cost of which, landed in Halifax, was $114.11. Further particulars as to the cost of the work, etc., will be found in the Schedule, under headings Numbers 5 and 7.

The results obtained from these experiments were only partially satisfactory. They showed that scraping machines could be cheaply driven by water pressure alone through the large pipes; but as it was found on examination—after the passage of the scraper several times through the pipes—that all the incrustation had not been removed, some improvement would have to be effected before the method could be pronounced perfectly successful.

In 1881 the author had made, under his own directions, new scraping machines for the 24-inch, 20-inch, 15-inch, 9-inch and 6-inch pipes, and proceeded to operate on the mains shown in Plate III. (which is a general plan of the Works), and more particularly described in the Schedule.

The design adopted for the scrapers was substantially the same as that of the experimental machine, with the exception that, in the large scrapers, small additional springs were attached to the pistons, in order —on account of their great weight—to keep them as nearly as possible in the centre of the pipe, and in all of them strong rubber springs were inserted beneath and a little in front of the knives or cutters, so as to ensure, as far as practicable, their contact with the interior of the pipes. (See Fig. I.) These rubbers were not attached until after a scraper had made one run without them, as it was feared that the extra friction caused by them would occasion stoppages, if used in any pipe that was badly corroded.

The 24-inch low service main was the next selected, and the first portion operated upon was the end nearest to the city. The scraper was inserted in the hatch-box at St. Andrew's Cross, with the intention of sending it westwardly, or in a direction opposite to the natural flow of the water in the main, on account of the steep rise in the gradient from

the head of the Northwest Arm towards the city. (See Plates III and IV.) It was subsequently found that this precaution was unnecessary, as the machine, although it weighed about 1 000 pounds, could be propelled up-hill with as much certainty as on a level or in a downward direction. The scraper was started by turning the high-service water into the low-service main behind it. It traveled off at a low and pretty regular rate of speed, making a rumbling noise as it went—so that it could easily be followed and its exact position readily detected, except when the sounds were drowned by the rattle of passing vehicles—and passed out with great force at the open hatch-box near the head of the Arm in just one hour after it had been started. The pressure indicated on the gauge attached to the 24-inch main at St. Andrew's Cross never exceeded 6 pounds during the operation, and the distance between the hatch-boxes or the length traveled was 6 875 feet. After the machine was given another run through the same length, it was removed to Lower Chain Lake and inserted in the 24-inch main at the hatch-box at that point. The head of water on it was from 9 to 10 feet, but as it was considered doubtful that this would be sufficient, a connection with the high-service supply was previously made by means of a 15-inch pipe, so that the pressure could be increased if wanted; this, however, was found unnecessary, as the scraper started off—without any assistance from the high-service—at a good brisk pace, and its speed increased so rapidly as it advanced down-hill (see Plate III), that the workmen were unable to keep up with it. The distance from the starting point to the hatch-box near the head of the Arm, where it emerged, was 6 525 feet, and the time taken to travel this distance was, in its first run, 15 minutes, and in the second 12 minutes. The latter or intermediate hatch-box was then closed, and the scraper was sent through the whole length of the low-service main, a distance of 2 miles 200 feet, in one run, which it accomplished in two hours in the first and 1 hour and 50 minutes in the second trial. Its rate of speed varied greatly, taking in the first instance 15 minutes to travel the first 5 000 feet, 14 minutes to the next 1 525 feet or to the intermediate hatch-box, 16 minutes to reach the Quinpool road, a distance of 1 700, and 75 minutes to St. Andrew's Cross, 5 175 feet. In the second instance, the same points were passed in 14, 13, 15 and 68 minutes respectively.

By looking at the profile (Plate III) it will be seen that the 20-inch high service main is at high elevation, and is not far from a level gradient for its whole length of 6 500 feet. As it was feared that the normal pres-

ure of the water would not be sufficient to force the machine through this pipe the proper attachments were made, and a pumping engine was sent to Spruce Hill Lake in order to increase the pressure if it should be found necessary. The scraper was inserted at the hatch-box near the lake, shown in Plate III, and although there were only 8 feet 10 inches of water above it, it started off and completed its journey of 6 000 feet to the next hatch-box at the commencement of the 15-inch main in 37 minutes without any assistance from the steam pump. The second run through the same main was made in 34 minutes.

The 15-inch high service main was then cleaned out in three sections, as indicated by the positions of the hatch-boxes shown in Plate III, their respective lengths being 16 100, 6 525 and 6 875 feet. The scraper in its first run travelled the whole length of the first section in 1 hour and 1 minute, the second in 1 hour and 10 minutes, and in the third section, which was that nearest to the city, it stuck fast at about 600 feet from the hatch-box near the head of the Arm. It was at the time working under a pressure varying from 45 to 50 pounds on the square inch, and after it stopped in its course the gauge indicated 65 pounds. The valves were then opened full and the pressure gradually increased up to 101 pounds, which was the limit attainable at that point. All this proved of no effect as the scraper still remained stationary, and the main had to be cut open to get it out. Its presence was easily detected by the noise made by the water rushing past it when a high pressure was maintained. On opening the main it was found firmly wedged into the pipe by a large piece of lead of irregular shape, weighing about 30 pounds. In laying the pipes this lead had run through one of the joints, and hence caused the stoppage. Other large pieces of lead, besides stones of all sizes (the largest about 9 inches in diameter), a sledge hammer and pieces of broken pipes were brought out by the scrapers at other times; but this was the only occasion where an obstruction of any kind caused a stoppage in the machine so that it had to be cut out.

The pipe was then made good and the scraper again started off on the third section, through which it passed, without any further trouble, in 35 minutes. After some further operations on these sections separately the scraper was sent through the whole length of the 15-inch main in one run. It was inserted at the end of the 20-inch main and the full pressure gradually turned on. The hatch-box at Lower Chain Lake (16 100 feet) was passed in 1 hour and 5 minutes, the hatch-box near the head of the Arm

(22 625 feet) in 1 hour and 40 minutes, and St. Andrew's Cross (29 500 feet) was reached in just 2 hours from the time of starting, making the average rate of speed nearly 3 miles per hour.

The pipes cleaned in the previous year were then recleaned with the improved scrapers, new hatch-boxes were provided where they had previously been omitted, and permanent brick man-holes were built, a full account of the expense of which will be found in the following schedule :

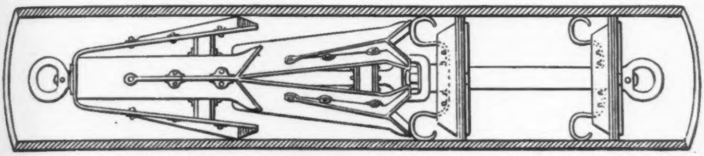


Fig. 1

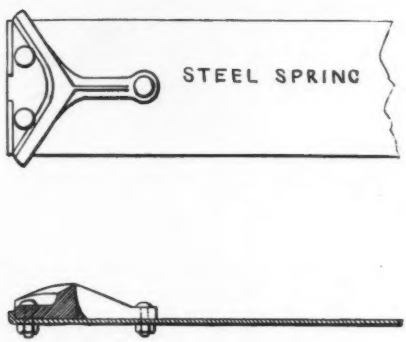


Fig. 2.

Schedule, Giving Cost of the Work and other Particulars.

No.		Cost of Labor.	Cost of Materials.	Cost of Labor and Materials.	Total.	Cost per Lineal Foot.	Remarks.
		$	$	$	$	Cents.	
1	24″ Main.—Length cleaned, 13 400 feet.						This pipe had apparently been coated with Dr. Smith's preparation. The surface was found nearly covered with nodules, from ½ to 1 inch in diameter, irregularly distributed. Pipe thoroughly cleaned.
Work done in 1881.	Age, 19 years.						
	Cleaning, including cost of scraper.	120 64	332 85	453 49	....	3.384	
	Man-holes of brick and stone.....	....	....	139 12			
					592 61	4.420	
2	20″ Main.—Length cleaned, 6,000 feet.						Apparently coated with Dr. Smith's preparation. Found in about the same condition as No. 1; the nodules being fewer, smaller and further apart. Pipe thoroughly cleaned.
Work done in 1881.	Age, 13 years.						
	Cleaning, including cost of scraper and hire of engine...........	85 11	192 88	277 99	....	4.633	
	Man-holes of rubble stone, dry..	....	....	48 24			
					326 23	5.437	

3	Work done in 1881.	15" PIPE.—Length, 29 500 feet.						First portion coated with Smith's preparation, and found same as No. 2. The remainder completely covered with heavy incrustation, about $\frac{3}{4}$ of an inch in thickness; probably not coated originally with any preparation. Pipe thoroughly cleaned.
		Age of first 16 100 ft. = 13 years						
		" remainder, = 25 "						
		Cleaning, including scraper.... ..	248 10	162 05	410 15	....	1.390	
		Man-holes of brick and stone....	....	....	83 63	493 78	1.674	
4	Work done in 1881.	15" PIPE.—Cogswell street.						Probably not originally coated with any preparation. An irregular incrustation found within the pipe from $\frac{3}{8}$ to $\frac{5}{8}$ of an inch in thickness. Pipe thoroughly cleaned, as far as could be ascertained.
		Length, 3 200 feet.						
		Age, 19 years.						
		Cleaning, not including scraper...	31 69	58 05	89 74	....	2.804	
		Man-holes of brick in cement.....	....	....	76 76	166 50	5.203	
5	Work done in 1880.	12" Pipe.—Cogswell street.						Probably never coated with any preparation. Average thickness of incrustation, about one inch. This was the first pipe cleaned. No man-holes were built. The first scraper used did not remove all the incrustation.
		Length = 3 200 feet.						
		Age = 33 years.						
		Cleaning, including $\frac{1}{2}$ the cost of scraper (only one hatch box set)	....	....	....	230 00	7.190	

SCHEDULE.—(*Continued.*)

No.		Cost of Labor.	Cost of Materials.	Cost of Labor and Materials.	Total.	Cost per Lineal Foot.	Remarks.
		$	$	$	$	Cents.	
6	RECLEANING No. 5 in 1881.						The improved scraper used in re-cleaning brought out a very large quantity of incrustation; apparently as much as taken out by original scraper in 1880. Pipe left perfectly clean, as far as could be ascertained.
	Cost, exclusive of scraper, but including one new hatch box.....	15 19	19 50	34 69	....	1.084	
	Man-holes, brick in cement......	....	....	76 76	111 45	3.483	
7 Work done in 1880.	12" PIPE.—Brunswick street.						This pipe was probably not coated originally with any preparation. Average thickness of incrustation, about $\frac{3}{4}''$. No man-holes built. Pipe only imperfectly cleaned.
	Length = 3 800 feet.						
	Originally laid elsewhere in 1848. Taken up, cleaned by hand, and laid in present position in 1862 and 3.						
	Cleaning (including one-half cost of scraper and one hatch-box only).....................	....	....	....	224 00	5 894	

8	Recleaning No. 7 in 1881.						Same as No. 6.
	Cost (exclusive of scraper, not including one hatch-box)	19 00	21 50	40 50	....	1.066	
	Man-holes, brick in cement......	....	....	103 81	163 81	4.313	
9 Work done in 1881.	12″ Pipe.—Cornwallis street.						Pipe not coated originally with any preparation. Incrustation same as No. 7. Pipe left perfectly clean, as far as could be ascertained.
	Length = 3 700 feet.						
	Pipe originally laid elsewhere in 1848. Taken up, cleaned by hand, and laid in present position in 1862.						
	Cleaning (including 2 hatch-boxes, but exclusive of cost of scraper)	33 63	49 50	83 13	....	2.247	
	Man-holes of brick in cement....	....	....	99 13	182 26	4.926	
10 Work done in 1881.	6″ Pipe.—Gottingen street.						Pipe not coated originally with any preparation. Average thickness of incrustation, $1\frac{1}{4}''$. Work stopped for the season, on account of wet weather.
	Only 295 feet yet cleaned.						
	Age = 33 years.						
	Cleaning (including scraper).....	49 72	68 43	118 15			
	Man-holes of brick in cement....	....	....	168 68	286 83		
	Total cost, including all work and materials = ...				$2 777 47		

No. 10, which was a pipe of 6 inches in diameter, was the smallest in which the attempt was made to remove the incrustation by means of a self-acting scraper. The thickness of the incrustation in this case averaged fully 1¼-inches, and the difficulty experienced in removing it, even for the short length of pipe operated upon, was considerable. The scraper would only travel a few feet at a time, and would then become firmly embedded in the iron rust which accumulated in a dense mass ahead of it, preventing its further progress. After several attempts to force it through, which were attended with some breakages and involved cutting the pipe to get it out, the operation was abandoned for the season, as wet weather began to set in, and it was evident that some other kind of machine or method of procedure would have to be adopted in order to remove the great bulk of the corrosion before the ordinary scraper would pass through as it had done in the other cases. A new and smaller machine, capable of being extended to the full diameter of the pipe, is now being made with only four arms and knives instead of eight. The centre rod is in one piece and hollow, with a nozzle at the front end, the object of which is to have a powerful jet of water playing immediately in front of the scraper to remove and prevent the detached iron rust from forming into a solid mass so great as to cause an obstruction. If this plan should not prove successful it is probable that, in order to clean all the small pipes, which are badly corroded, they will have to be opened temporarily in short lengths of 400 or 500 feet and the scraper be pulled through for the first time with a wire rope, after which it is not anticipated that there will be any difficulty in propelling it by water pressure alone.

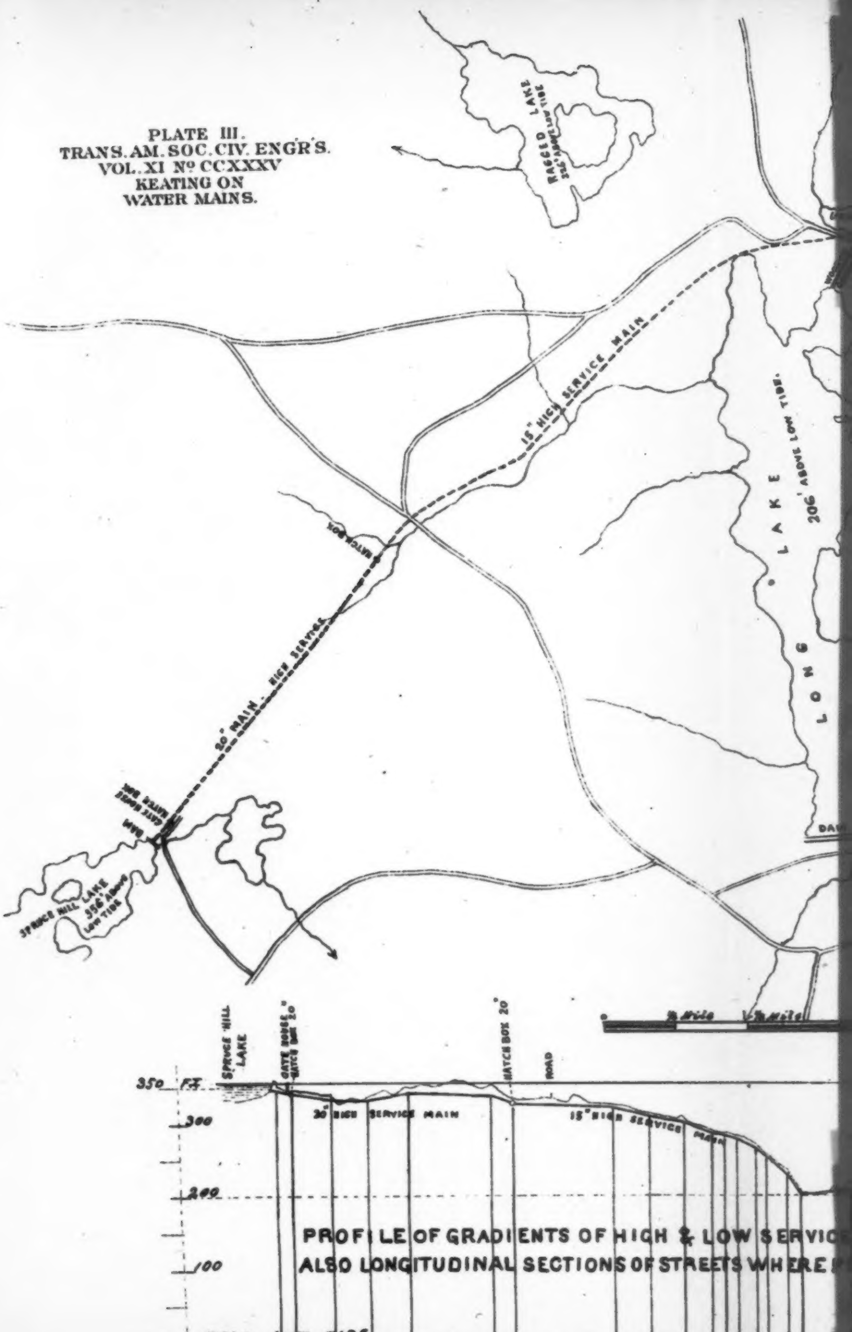
The entire expense attending these cleaning operations, where the pressure of water only was used as the motive power, including the cost of hatch-boxes, man-holes and the drains from them to the nearest sewers, repairs to the machines and to broken or damaged pipes, and all other charges connected with the work, was, as the schedule shows, $2 777 47. If, however, we deduct No. 10, which is only partially done, and Nos. 6 and 8, which are for recleaning the pipes scraped out in 1880, the cost will stand as follows :

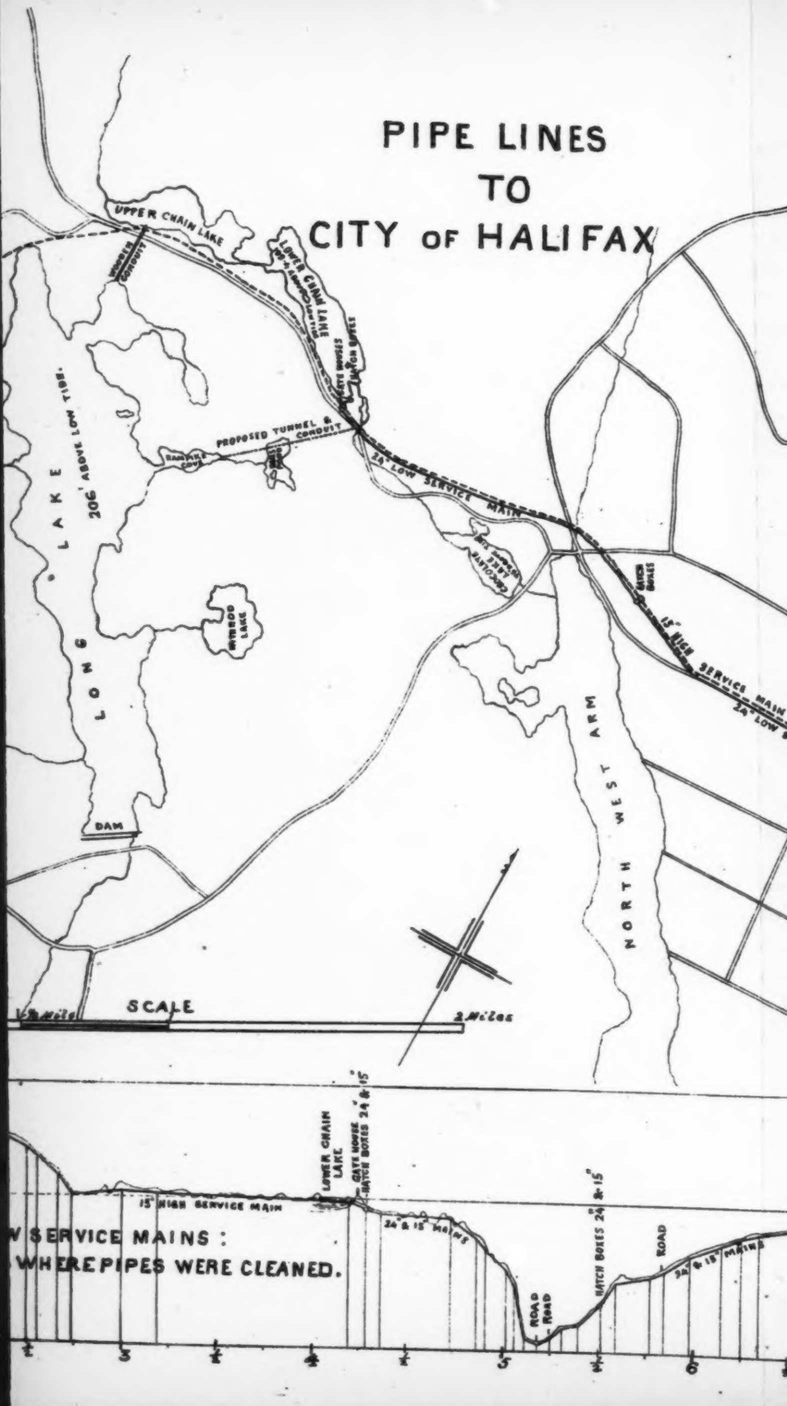
Total length of old 24-inch, 20-inch, 15-inch and 12-inch pipes cleaned = 62 800 lineal feet, or nearly 12 miles.

Total cost, not including man-holes = $1 768 50 = 2.816 cents per foot.

Total cost, including man-holes = $2 215 38 = 3.528 cents per foot.

PLATE III.
TRANS. AM. SOC. CIV. ENGR'S.
VOL. XI Nº CCXXXV
KEATING ON
WATER MAINS.




PIPE LINES
TO
CITY OF HALIFAX
UPPER CHAIN LAKE
WOODEN CONDUITS
LOWER CHAIN LAKE
GATE HOUSES
HATCH BOXES
PROPOSED TUNNEL & CONDUIT
24" LOW SERVICE MAIN
206' ABOVE LOW TIDE.
LONG LAKE
CHOCOLATE LAKE
HATCH BOXES
15" HIGH SERVICE MAIN
24" LOW
NORTH WEST ARM
DAM
SCALE
2 Miles
LOWER CHAIN LAKE
GATE HOUSE
HATCH BOXES 24" & 15"
15" HIGH SERVICE MAIN
24" & 15" MAINS
W SERVICE MAINS :
WHERE PIPES WERE CLEANED.
ROAD
ROAD
HATCH BOXES 24" & 15"
ROAD
24" & 15" MAINS
3
4
5
6

BEDFORD BASIN
TO QUEBEC
COTTON FACTORY BRANCH RAILWAY
INTERCOLONIAL RAILWAY
THE NARROWS
RICHMOND
COTTON FACTORY
PART OF THE CITY OF HALIFAX
HALIFAX HARBOUR
NORTH STREET
GOTTINGEN STREET
BRUNSWICK STREET
CORNWALLIS STREET
COGSWELL STREET
COMMON
CITADEL
SERVICE MAIN
24" LOW SERVICE MAIN
15" PIPE
12" PIPE
ST. ANDREW'S CROSS
350 FT.
300
200
100
0
7
8 MILES
ST. ANDREW'S CROSS HATCH BOXES AT END OF 24" & 15" MAINS
15" MAINS
COMMON
PARK ST.
CITADEL
BRUNSWICK ST.
WATER ST.
NORTH ST.

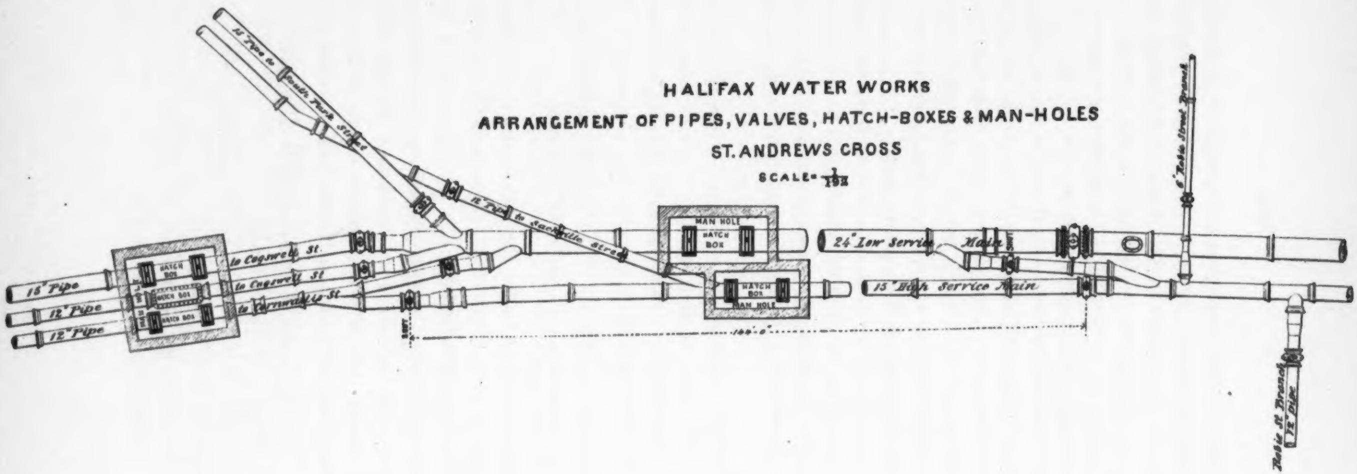

HALIFAX WATER WORKS
ARRANGEMENT OF PIPES, VALVES, HATCH-BOXES & MAN-HOLES
ST. ANDREWS CROSS
SCALE = 1/192
15" Pipe to South Park Street
12" Pipe to Sackville Street
MAN HOLE
HATCH BOX
24" Low Service Main
15" High Service Main
6" Robie Street Branch
Robie St. Branch
12" Pipe
15" Pipe
12" Pipe
12" Pipe
to Cogswell St.
to Cogswell St
to Cornwallis St.
144'-0"

PLATE IV.

It should, perhaps, have been mentioned that no pumping apparatus was needed to free the man-holes of water, as in most cases they were connected with the sewers by short drains and where no sewers existed within a convenient distance they were allowed to overflow.

Fig. 1, page 135, is a drawing of one of the large scrapers as used in the final operations. The cutters or knives were found to wear down rapidly after a machine had been a short time in use, so that they soon became almost useless, and others had to be added. To obviate this difficulty in the future the author is now having made chilled cast iron cutters, as shown in Fig. 2, which can be simply bolted to the end of the steel spring and replaced at a few moments' notice without the necessity of sending the scraper to the machine shop.

The effect of removing the incrustation from the mains was most marked and beneficial upon the water supply to the city, and will be at once seen by comparing the pressures taken at the 25 hydrants on the wharf properties along the harbor in the month of February, 1880, 1881 and 1882.

In making a comparison it is, however, necessary to bear three things in mind which tend to show that the result of these partial cleaning operations has been even more favorable than the pressures would indicate. They are as follows:

1st. That the incrustation in the pipes was annually rapidly increasing and the pressure was consequently decreasing.

2d. That in 1880 and 1881 the high service supply was augmenting the low service, which supplied the hydrants on the wharves, and that in 1882 this was no longer the case.

3d. That in the winter of 1881 a pretty rigid inspection to detect and prevent waste was maintained, and fines were imposed wherever it was brought to notice. There was no inspection made in the winter of 1880, nor has there been any during the present winter of 1882.

The total pressure on the 25 hydrants in February, 1880 = 856 pounds, or an average of 34.2 pounds each.

The total pressure on the 25 hydrants in February, 1881 = 1 088 pounds, or an average of 43.5 pounds each.

The total pressure on the 25 hydrants in February, 1882 = 1 309 pounds, or an average of 52.4 pounds each.

If we omit from the comparison the pressures taken in February, 1881, as they certainly should be omitted, on account of the efforts made in that year to suppress waste, the result shows that the effective pressure in the city has been increased a little over 50 per cent., without taking into account the fact that the High Service Supply no longer aids the Low Service, as it did in 1880 and 1881, but that it is now confined to within its own limits.

If we now turn to the High-service, probably the best example to take will be the highest part of the city supplied with water, which is in the neighborhood of the new cotton factory. The most elevated plug in this vicinity is at the intersection of Almon street and Kempt Road, and the pressures taken at the same times as those previously given stand as follows :

The pressure	taken	in	Feb.,	1879,	was	8	lbs. on	the square inch.
"	"	"	"	1880,	"	8	"	"
"	"	"	"	1881,	"	28	"	"
"	"	"	"	1882,	"	34	"	"

Although this example shows an increase of over 400 per cent since 1880, the actual increase in the whole service, though very greatly augmented, is not truly represented, as it was nothing like that amount; still it shows truly the effect at that point.

Other examples quite as striking could be given, and at several points where formerly the water would not flow from the nozzles of the hydrants, there is now a pressure of from 12 to 19 lbs. on the inch in the coldest weather in winter, and up to the present date (23d February, 1882) there has not been a single complaint of insufficient supply since the winter began, where formerly there used to be hundreds.

During the past summer the author was consulted with reference to removing the incrustation from a 6-inch main (which was very badly corroded) supplying Mount Hope Lunatic Asylum, in the town of Dartmouth. The pressure some years ago had become so poor that the water would not rise to the tanks in the top of the building without the aid of a steam pump, which had to be kept going almost constantly ; but ultimately even this provision was found insufficient, as the main did not deliver the water quickly enough to keep the pump going at a moderate rate of speed.

The commissioners for the asylum, who contemplated laying a new and larger main, were advised to try the effect of cleaning operations, upon which advice they acted.

The main, which was 1¼ mile in length, was found reduced by the corrosion to about 4 inches in internal diameter, and as the head of water at the upper end was small, a steam fire-engine was employed to force the scraper through. In the first trial the machine only traveled about 70 feet, when it stopped at an old break in the pipe and had to be cut out. After repeated trials, in which, at times, the pressure was as high as 120 lbs. on the inch, it was found that the stoppages caused by obstructions of various kinds were so many that the commissioners became disheartened, and, without attempting any alteration or improvement in the scraper, they decided to change the method of procedure—to open the main in short lengths and to pull the machine through by manual labor. At this time the scraper had gone only about 1 000 feet. A great many obstructions were encountered under the altered plan in the shape of lead and stones, and in one case a large piece of wood caused a stoppage. Sometimes the machine could be drawn ahead only a few feet, when the main would have to be again cut to extricate it. Finally, after the obstructions and the great bulk of the rust had been removed, the scraper was sent through the main from end to end, without any assistance from steam power, and it traveled the whole distance in 27 minutes. Permanent hatch-boxes and man-holes were then built at each end, so that the machine can now be sent through as often as desired, at very trifling expense.

The following is a statement of the cost of these operations :

Labor list	$291 70
Materials	116 83
Hire of engine	160 25
Halifax Board of Works for pipes, sleeves, hatch-boxes, scraper and labor	362 36
Total	$931 14

or 14.108 cents per lineal foot.

The effect of cleaning this main was immediately felt at the asylum. There is no further occasion for the stationary engine and pump to force the water to the tanks, as they now overflow by the force of gravity

alone, and it is stated that the saving in the one item of coals will be about $700 per annum.

In discussing the above paper several questions were asked, which the Secretary transmitted to the author, Mr. Keating, and received the following answer:

In reply to your communication asking for some further information respecting the pipe cleaning operations carried out in this city, together with an analysis of the water, as a supplement to my paper on "The Removal of Incrustation in Water Mains," I have much pleasure in submitting to you the following remarks, in which I will endeavor to answer the questions which have been raised.

All the large scraping machines used in our operations were made on the same principle, as shown on the drawing submitted (Fig. 1). They are extremely simple, consisting of a stout centre wrought iron rod, in two pieces, coupled together in such a manner as to allow of a little play, so that the machine may pass round any ordinary bends or angles in the pipe line. There are eight arms of spring steel, varying in width and thickness, according to the diameter of the pipe. Each of these arms has barbed cutters attached to it, which do all the work in removing the incrustation from the pipes, the backward set of four being so placed as to cut away everything that may have escaped the front set of cutters. The arms are also so arranged that they will yield inwards in case of the cutters striking against any solid obstruction, such as a ferrule projecting into the pipe, which would otherwise cause the machine to stop. The forward part of the cutters is tapered towards the centre of the pipe, with the double object of cutting or splitting longitudinally any heavy incrustation of iron rust, and also of preventing the barbed knife from catching in any defective or open joint in the pipes, which would also cause a stoppage. The pistons do all the work in propelling the machine forwards; they are made double in order to ensure steadiness, and they do not do any cutting work whatever. Each is composed of a heavy disk of cast iron, at the back of which the leathers are placed, attached to small leaden or cast iron plates, in sections, so as to give them additional stiffness in one way, and yet so as to allow them to yield backwards, to pass any obstruction not removed by the cutters. The small springs attached to the pistons are placed there for the purpose of

maintaining the machine exactly in the centre of the pipe, which provision is necessary in all large scrapers, on account of their great weight; these springs also preserve the leathers from being rapidly worn out. The heavy rubber springs must be regarded as auxillary to the main springs or arms, and should not be attached until the machine has made one or two runs through the pipe without them. If other and heavier steel springs are provided for final operations, the rubbers may be discarded. The large rings at each end of the scraper are of no service except for convenience of handling, and in the case of small scrapers for the purpose of hauling them through the pipes in the event of that becoming necessary. In the manufacture of any new machines, I would substitute a heavy nut in the place of each of these rings. The new knives or cutters which—it was stated in the original paper—were to be made of cast iron chilled, are now to be made of cast steel.

The scrapers are all propelled forwards in the direction of the barbed cutters, the pistons being hindermost. They cannot be forced through the pipe in the wrong direction, *i. e.*, with the pistons foremost, as the leathers would bend over, and the greater portion of the force of the water would be lost; and if the machine should move a short distance, it would soon be brought to a standstill by the corners of the knives catching in the slightest irregularity in the pipes, or in any joint that might happen to be a little open.

With regard to the coating on the pipes, I can only say, that where it has been used at all (see remarks in the schedule), to all outward appearances, it is the same as that known as the preparation of Dr. Angus Smith. In the case of the 20-inch high service main laid 13 years ago, which had been coated apparently by Smith's process, about half the interior surface of the pipe was covered with numbers of nodules or carbuncles of iron rust, varying in size from about ¼ inch up to about 1½ inches in diameter, and projecting into the pipe from about ⅛ inch to ⅜ inch; in many places these nodules had formed in clusters, and, as it were, had grown together, forming little patches of incrustation. The removal of these by the scraper left the surface of the pipe apparently in nearly as good condition as it was originally, with the exception that where each nodule or patch of incrustation had commenced to form, it could be plainly seen that the process of decay had commenced, the rust having eaten through the coating only in small spots, like pin-holes, leaving the great bulk of it in its original condition.

With reference to an analysis of the water, I regret that I cannot give you as full information as I would wish. Although the low service water has been carefully tested on different occasions, I am not at liberty to publish the most full analysis that has been made, and the high service water has never, to my knowledge, been subjected to any complete or careful chemical tests.

A sample of water taken from the middle of Long Lake, in September, 1878, and analyzed by Professor George Lawson, of Dalhousie College, Halifax, yielded

Inorganic matter	1·71	grains per gallon.
Organic "	2.13	" "
Total	3·84	" "

Another sample taken on the same date from the inlet to the city at Lower Chain Lake, yielded

Inorganic matter	2·44	grains per gallon.
Organic "	2·68	" "
Total	5·12	" "

The following additional extracts from the report of Professor Lawson may be of interest:

" The inorganic matter consisted principally of alumina and iron, with silica (soluble), common salt, and a mere trace of lime. The water belongs to the class of soft waters, such as are collected in districts where there are no chalk or limestone strata, or other rocks capable of yielding soluble substances."

"It is obvious that the excess of impurity is taken up by the water in its course from Long Lake, through the Chain Lakes, to the city inlet.

" The source of the impurity was discovered in upper Chain Lake in the form of a deposit of a very peculiar character, in the bed of the lake. It extends apparently over the greater portion of the lake bottom, and is of a thickness so great that in several places a long crow bar almost disappeared in it without reaching bottom. The substance of this deposit varied in consistence from that of soft cheese to common baker's bread; it varied in color from whitish or light skin color to dark ferruginous brown, some pieces being nearly black. It consists, to a very large ex-

tent, of the remains of microscopic organisms belonging to the class called Infusoria. The following chemical analysis will show the composition of the substance :

"DEPOSITS FROM BED OF UPPER CHAIN LAKE.

"Sample No. 1 (pale brown, slightly ferruginous).

Total amount of Inorganic Matter (buff-colored ash)		49.76
Insoluble in hydrochloric acid (silicious infusorial earth, etc)	38.40	
Soluble in hydrochloric acid (Iron Alumina, etc.)	11.36	
Organic Matter		11.32
Water		38.92
		100.00

"Sample No. 2 (pale whitish skin-colored).

Total Inorganic Matter (delicate skin-colored ash)		48.40
Insoluble in HCl	38.96	
Soluble in "	9.44	
Organic Matter		9.60
Water		42.00
		100.00

"Sample No. 3 (Intermediate in color, between Nos. 1 and 2).

Total Inorganic Matter		49.20
Insoluble in HCl	38.16	
Soluble in "	11.04	
Organic Matter		8.72
Water		42.08
		100.00

"Sample No. 4 (dark ferruginous brown, hygroscopic, not drying in air like the others).

Total Inorganic Matter	24.70
Organic Matter	11.85
Water	63.45
	100.00

"The deposit has, no doubt, originally consisted of swamp muck, formed by the remains of plants, infusoria, &c., but by long subjection to the action of water passing over it has lost much of its organic matter. In the first three samples, which are of light color, and dry up like bread when exposed to the air, the organic matter (after deduction of water) amounts to about 16 per cent., whereas in the sample No. 4, which is of dark color, and remains wet, the proportion is nearly 32 per cent., just double. The process of gradual washing out of the soluble organic matter from the deposit, by the water of the lake, is well illustrated by the light color on the surface where it is in contact with the water, and the dark color beneath, seen when the upper layer is removed.

"It may be added that a few specimens of fresh water spnoge (*spongilla*), (whose decay gives a very offensive odor to water), were found in upper Chain Lake, but neither there, nor in the other lakes, were any of the plants found which are commonly known to render water noxious. In Spruce Hill Lake the surface of the water was, in many places, especially near the shore, of a brilliant green color, from the growth of a microscopic alga called *Trichormus Flos-aquæ*, which has been observed to give a green color to the water in the Grand Canal Dock at Dublin, and has been observed also in Scotland, France, Wales, Germany and Finland. It is not known to be injurious, but is regarded as an indication of water being stagnant or containing organic matter."

I might add to this report of Professor Lawson that some of the impurity is, no doubt, due to the circumstance that a public road which is much frequented skirts along the shores of the Chain Lakes for about a mile, and that the drainage is directly into the lakes just above the inlet.

It should be borne in mind that the above samples of water were taken from the lakes in the autumn, when they were at a lower level than they have ever been known to reach before or since, and as the Chain Lakes are shallow and boggy ponds, it is inferred that the analysis given shows a greater amount of impurity than the water would be found to contain when in its normal condition.

An analysis made from some water taken from a tap in the city (supplied from the low service) in the autumn of 1873 yielded:

Total solids, less than 2 grains to the gallon.

Organic Matter, very small.

Professor Lawson states in his report that the inorganic matter consisted principally of alumina and iron, with silica (soluble), common salt and a mere trace of lime. It is owing to the absence of lime in the water that the rapid formation of oxide of iron in the pipes is attributed.

The following circumstance will show how rapid this formation is when the water is brought in contact with unprotected iron.

Four years ago a private citizen laid about 400 feet of ordinary wrought-iron one-inch gas piping (unprotected) for the purpose of conducting the water to his dwelling. The whole length of this pipe is now completely filled with iron rust so that no water will pass through it.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
INSTITUTED 1852.

TRANSACTIONS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

CCXXXVI.
Vol. XI.—April, 1882.

ON THE MODE OF UNDERPINNING ADOPTED FOR THE CROTON LAKE BRIDGE, N. Y. C. & N. R. R., DURING THE REPAIRS TO THE MASONRY PIERS.

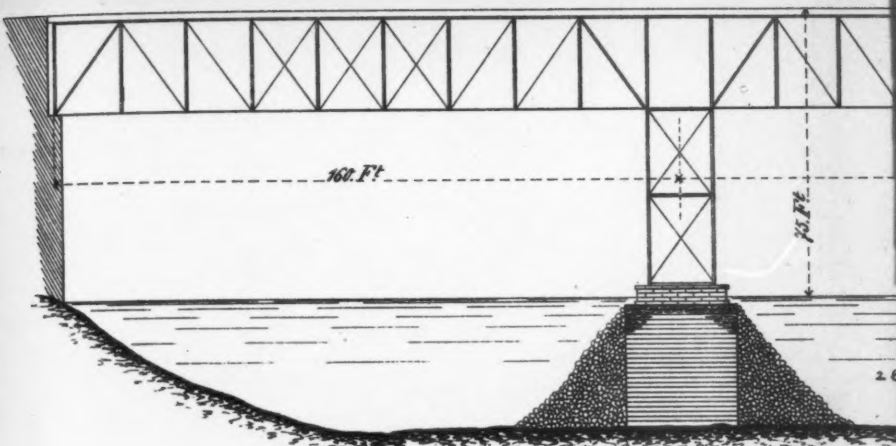
By ALFRED P. BOLLER, Member A. S. C. E.

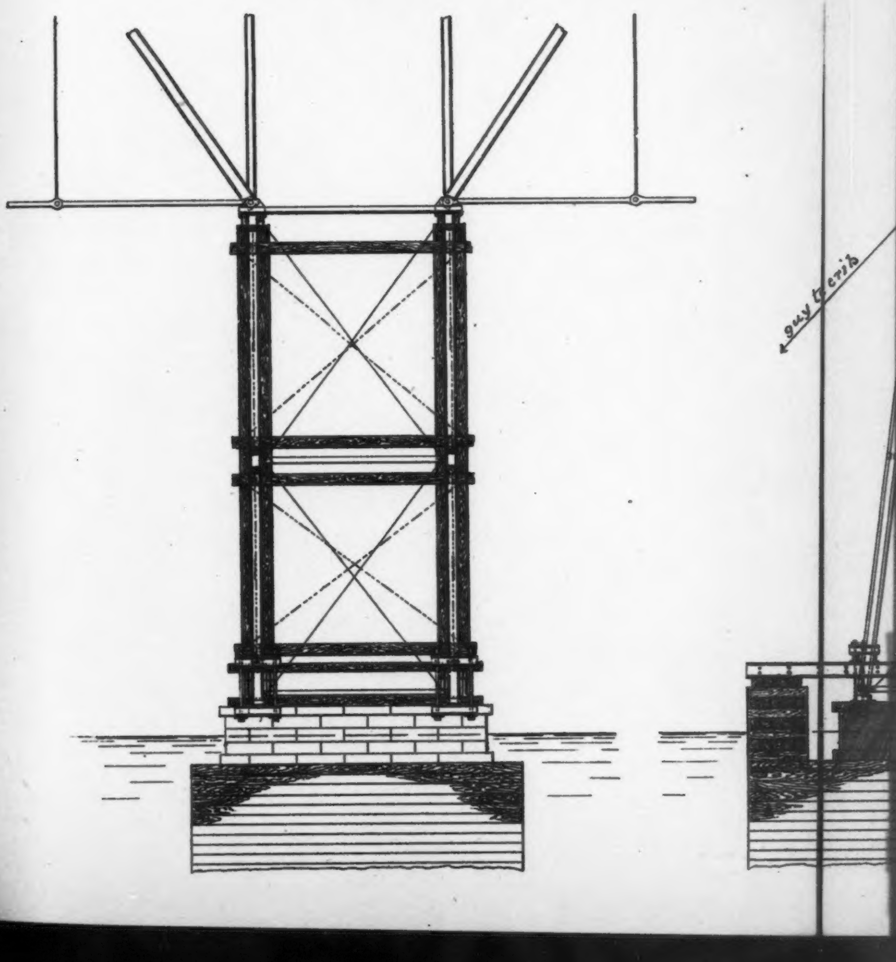
READ APRIL 5th, 1882.

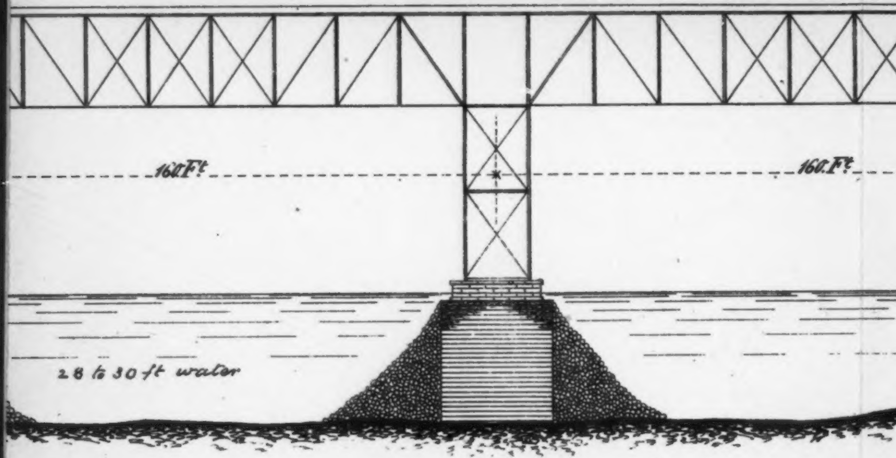
Inasmuch as methods of doing work are as instructive as a study of work accomplished, the writer offers to the Society an experience of his own, which may be suggestive to others when called upon to meet similar problems. The Croton Lake Bridge was built by the writer during

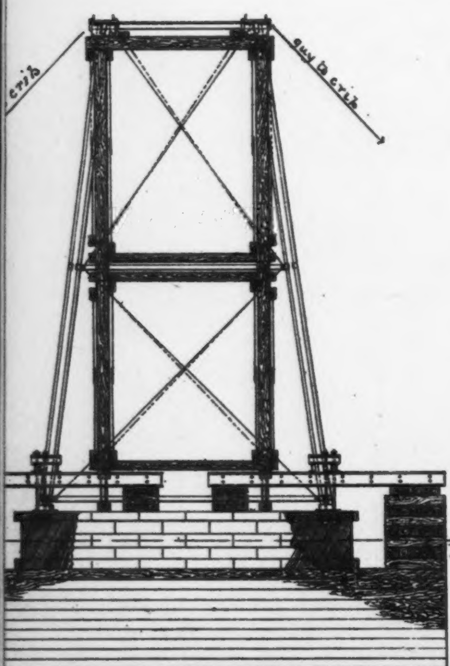
the summer of 1879 for the New York City and Northern Railroad Company, its general features being illustrated, so far as the purposes of this paper are concerned, on the accompanying Plate V. It is a single track wrought-iron deck structure, in three spans of 160 feet, with skeleton piers or towers springing from blocks of masonry, as shown. The towers have four legs, and therefore concentrate all weight on the four corners of the masonry. This masonry had been put in some ten years before by the bankrupt New York, Boston and Montreal Company, and was tested at the time the iron bridge was built by loading with stone in cribs, without showing any improper settlement. While this answered to test the foundations as a mass, it did not represent the conditions of weight to be delivered to the masonry, as events afterwards disclosed. The proper way would have been to have tested with railroad bars, the weight of which it would have been easy to concentrate upon the area to be occupied by the shoes of the proposed tower legs; but such bars being unavailable, the former mode was resorted to. The blocks of masonry were supported on timber cribs made of plank, carried up to low water, with an outside protection of rip-rap, as shown. The masonry itself was very suspicious looking, being built with stones set up on edge, with an indescribable bond, and generous joints, well pointed. The needs of expedition and the shrinking of the controlling powers from the great cost of rebuilding them, settled the question of their use as they stood, and the erection of the iron work proceeded. It was not many months after the bridge was in use before the masonry disclosed its real character; the pedestal stones became cracked, and the bond at the corners commenced to separate. It was an ugly piece of business, and it was a long process of evolution before the writer devised the plan which was successfully carried out. Staging the whole of two spans, the water being 28 and 30 feet deep, was an expense not to be thought of, and it would have cost about as much to have straddled the piers, outside of the rip-rap, with wooden piers and trussed across the interval. The outcome of the study is well illustrated on the adjoining plate. The wrought iron towers being a continuous piece of framework from shoe to cap, it was determined to build an inside wooden tower, with all parts in pairs, so as not to interfere with or require any removal of braces or struts. This subsidiary tower being built with legs plumb, brought the points of support considerably within those of the iron legs. The bottom sills were so placed as to permit the introduc-

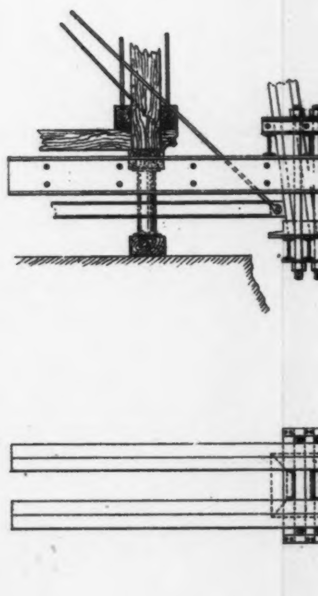
tion of eight 20-ton hydraulic jacks, bearing against sill pieces on the masonry. Fortunately the timber cribs afforded sufficient room on the outer edges to build solid timber supports. This was done, and 15"—200 lbs. per yard rolled beams were placed in pairs as shown, reaching on the inner side as far back as possible on the masonry, and the pressure well distributed with timbers. Two minutes work on the jacks served to lift the towers and adjoining spans bodily, when the defective masonry was racked out. The wrought iron saddles and suspension bolts were then attached, the whole weight transferred to them, and the structure was ready for traffic again, while the new cut work was being put in. While the drawing shows both sides so arranged, only *one* side of a pier was racked out at a time. As an additional precaution to lateral movement on such a high structure, wire rope guys were thrown out from the end shoes of the trusses and tower caps, and anchored to cribs sunk for the purpose. It is gratifying to state that the whole arrangement worked so perfectly that not a single train was delayed on its schedule time, and that a half-hour proved ample to raise the structure, rack out a clearance in the masonry, and make all attachments for throwing the weight on the iron cross girders. In this connection I desire to make mention of my foreman, Mr. Wm. H. Clough, through whose skill and careful supervision I was enabled to accomplish so perfectly one of the most satisfactory pieces of engineering work that has fallen to my lot to perform. Before closing this brief account of a temporary construction, the disclosures of those old piers is a story worth telling, and of all deliberate, studied, cold-blooded frauds, those piers are entitled to the highest rank, and should consign to infamy all parties concerned in their creation. They were nothing but the merest veneer, of stones set up on edge, with no cement detectable internally, and filled up with sand, stones and rubbish, an occasional barrel head, and a plentiful supply of engineers stakes, to "level up with." Many of the coping stones were actually cut cross-grained, and no expense was apparently spared in doing everything wrong. Such instances of cold-blooded criminality almost restore any waning faith one may have in a *hot* immortality.


160 Ft
75 Ft


guy to crib







MOD
CROT
DURI

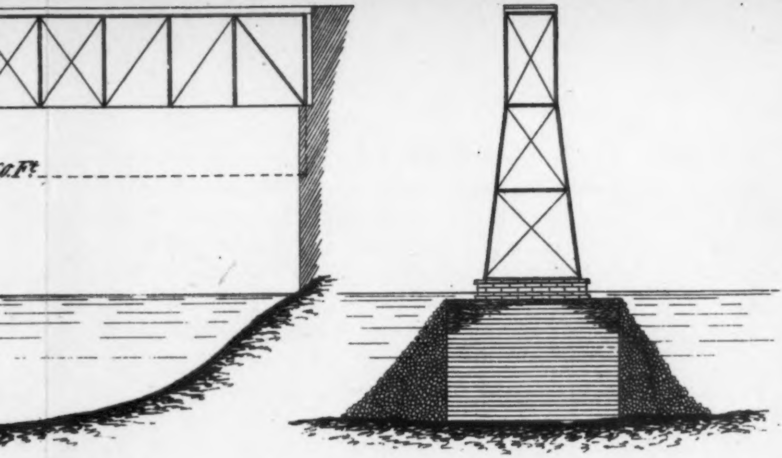
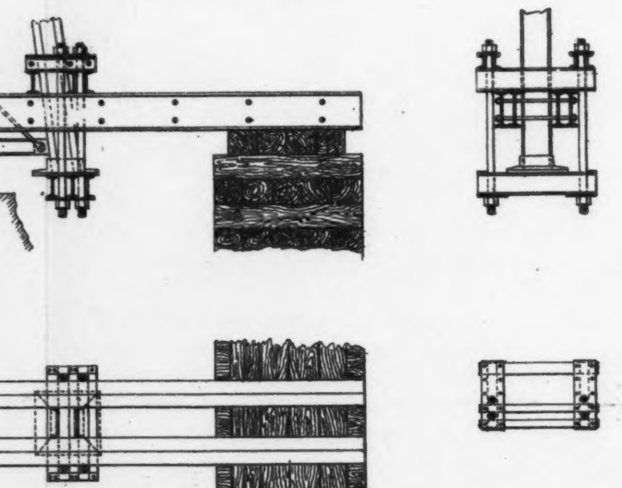


PLATE V.
TRANS. AM. SOC. CIV. ENG'R'S.
VOL. XI Nº CCXXXVI.
BOLLER ON
UNDERPINNING BRIDGE.



MODE OF UNDERPINNING, ADOPTED FOR
CROTON LAKE BRIDGE, N.Y.C & N.R.R.
DURING REPAIRS TO MASONRY PIERS
BY ALFRED P. BOLLER C.E.